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Indian Standard
CODE OF PRACTICE FOR
TREATMENT OF WATER FOR
HIGH PRESSURE BOILERS
(*First Revision*)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

CODE OF PRACTICE FOR TREATMENT OF WATER FOR HIGH PRESSURE BOILERS

(First Revision)

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Indian Standard

**CODE OF PRACTICE FOR
TREATMENT OF WATER FOR
HIGH PRESSURE BOILERS**

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 7 January 1983, after the draft finalized by the Boiler Water Sectional Committee had been approved by the Chemical Division Council.

0.2 The terms low, medium, and high, used with pressure in boiler practice, are not definite but relative. However, it is customary to call those boilers which operate at pressures below 2.0 MN/m^2 (20 kg/cm^2) as low pressure boilers; those working between 2.0 and 5.9 MN/m^2 (20 and 60 kg/cm^2) as medium pressure boilers; and those operating at pressures above 5.9 MN/m^2 (60 kg/cm^2) as high pressure boilers.

0.3 The treatment of water for low pressure boilers, is given in IS : 1680-1982*, which, though mainly prepared for the guidance of operation of low pressure boilers, is also applied to the operation of medium pressure boilers with the conditions given for them where necessary. The procedures laid down in this code are for general guidance of high pressure boilers only and each case has to be treated on its own merit, taking into consideration the plant cycle, equipment design and plant and process requirements. High pressure boilers are not riveted, they are welded and stress relieved. This fact has been one of the guiding considerations in formulating this code.

0.4 Earlier version of this code which was published in 1967, covered boilers operating at pressures above 4.1 MN/m^2 (42 kg/cm^2). As per the general practice, this revised standard has now been made applicable to boilers operating at pressures above 5.9 MN/m^2 (60 kg/cm^2). It also includes new sections on:

- a) Condensate purification (see 3.2);
- b) Control of concentration of solids in boiler water (see 4.3);

*Code of practice for treatment of water for low and medium pressure land boilers (third revision).

- c) Protection of idle boilers (*see* 5); and
- d) Care of high pressure drum-type boilers during condenser tube leakage (*see* 6).

However, chemical compositions of feed water, boiler water and condensate for water-tube boilers have not been given in this standard. These are given in IS : 10496-1983* along with recommendation for the application of the limits. Characteristics of water for once through boilers have also been given in that standard.

0.5 In the preparation of this standard, considerable assistance has been drawn from BS 2486 : 1978 'Recommendations for treatment of water for land boilers', issued by the British Standards Institution.

1. SCOPE

1.1 This code deals with the chemical methods of attaining the conditions to be aimed at in the water side of boilers operating at pressures above 5.9 MN/m² (60 kg/cm²) at the drum.

2. OBJECT OF TREATMENT

2.1 The chief object of treatment is to prevent corrosion of the boiler and fittings. For this purpose the composition of feed water, boiler water and condensate are maintained as given in IS : 10496-1983*. The water used for make up has to be of a very high purity, introducing as few harmful impurities in the feed as practicable. In most cases, the return condensate is the bulk of feed water and the make up is obtained from evaporated water or demineralized water. Thus it is free from any dissolved solids and the question of scale formation does not arise.

3. METHODS OF TREATMENT

3.1 As stated in 2.1, the make up is obtained from the following alternative sources:

- a) *Condensate or Evaporated Water* — Care shall be taken that it is free from oil. If any oil is present it shall be removed with the help of special oil-removal plants. The water shall be sufficiently alkaline, pH being above 8.5. If necessary an alkali is added to obtain this condition. It should contain very little silica. If the make up is obtained from evaporated water, and if it is softened by the lime-soda process before evaporation, addition of magnesium hydroxide or magnesium oxide along with softening chemicals would remove silica.

*Specification for feed water, boiler water and condensate for high pressure boilers.

b) *Demineralized or Deionized Water* — With silica removal

3.2 Condensate Purification

3.2.1 Condensate purification is a means of recovering contaminated condensate for re-use as feed water. Otherwise, it may have to be discarded and replaced by treated make-up water at extra expense. The principal sources of contamination are as follows:

- a) During commissioning and early operation of a boiler plant the condensate is usually contaminated with mill scale and other debris which increases the risk of corrosion of the tubes in a water-tube boiler. In a once-through boiler they may lead to abnormal pressure drops and unacceptable contamination of the steam. Silica can also be particularly troublesome during the period and the commissioning may be delayed by excessive demands for water brought about by the large amount of blowdown required to limit the levels of silica in boiler water and steam.
- b) Condensate is often contaminated for a period of several hours after start-up following an overnight or weekend shut-down and it may be necessary to reject such condensate from the system with a consequent increase in demand on the water supply.
- c) Some contamination of condensate by products of corrosion of the materials of construction occurs during normal operation and, even if other contamination is absent, purification plant may be necessary to meet the highest standards for chemical quality of feed water.
- d) Where steam is used for industrial process heating and is recovered as condensate, it may be contaminated by untreated water or by chemicals used in the industrial process. Precautions should be taken to prevent these contaminated condensates being returned to the boiler plant without treatment. Wherever possible such contamination of condensate should be prevented at source.

3.2.1.1 The decision to install condensate purification plant and the capacity and type of equipment depend upon the design, duty and feed water specifications of the individual boiler plant, and comparative costs.

3.2.1.2 When the condensate contains more than a trace of impurity it may be more economical to return it up-stream of the make-up water treatment plant rather than to install a separate plant to purify the condensate if the ionic load permits.

3.2.1.3 If economic considerations favour partial rejection of the condensate an automatic instrument should be used to monitor the

contamination and operate the rejection or recovery devices in accordance with the varying quality of the condensate.

3.2.2 Condensate Polishing — A plant is often provided for purification of slightly contaminated condensate that forms the major part of the feed to high pressure boilers. Such removal of traces of impurities, usually iron and copper, is referred to as 'condensate polishing'. This provision is of particular importance with once-through boilers and where condensate is recovered from industrial processes or heating.

3.2.2.1 Mixed bed ion-exchange, preferably externally regenerated to avoid contamination by regenerants, is an essential part of condensate polishing. It may be preceded by integral or separate cation exchange, with or without a filtration stage. Several types of filters have been used successfully, including precoat filters, paper cartridge filters and fibre-wound candles. Magnetic separators have also been used.

3.2.2.2 The purpose of the filter is to reduce the quantity of suspended solids reaching the iron-exchange units and hence lower the risk of fouling the resins. The integral or separate cation exchange unit also protects the mixed bed resins by removing a proportion of the suspended solids and, by reducing the cationic load to the mixed beds, helps to ensure that the highest quality of purified condensate is obtained. The cation resin may be used either in the hydrogen or in the ammonia form; the former gives greater purity but the latter may be cheaper to operate in some cases.

3.2.2.3 Two other systems have also been successfully adopted; mixed beds alone and filters precoated with expendable powdered or micro-bead resins, installed either alone or as a component of the condensate polishing plant.

3.2.3 Condensate Contamination by Cooling Water — Entry of cooling water into the steam and condensate system is a common cause of contamination of condensate. The cooling water may be fresh, brackish or sea water from once-through cooling systems, or treated water from a circulating evaporative cooling system in which dissolved solids have concentrated.

3.2.3.1 Condensates contaminated in this manner may usually be purified by treatment in a plant similar to that used for treatment of make-up water or, if the proportion of condensate is small, by adding the condensate to the raw water going to the make-up water treatment plant.

3.2.4 Condensate Contamination by Oil — Every effort should be made to avoid contamination of feed water by oil, if necessary by rejecting oily condensate.

3.2.4.1 Vegetable oils introduced into alkaline boiler water are usually converted into soaps that can rapidly form a stable foam on the surface of the boiler water and may lead to severe contamination of the steam. Where this risk exists, continuous addition of an antifoam is prudent even when contamination is not apparent.

3.2.4.2 Mineral oil introduced into the boiler may form non-wettable films on heat transfer surfaces and interfere with the detachment of steam bubbles so that the surfaces are inadequately cooled by the boiler water. As a consequence severe corrosion or failure of such surfaces may occur.

3.2.4.3 If sludge in a boiler absorbs oil it may become less mobile and obstruct circulation. Similar obstruction may occur in condensate lines and steam traps owing to the presence of oil, which is carried forward with the steam.

3.2.4.4 Various treatment processes are available for substantially removing small amounts of oil in condensate. Some of these processes are:

- a) Coagulation, flocculation and sedimentation in alkaline conditions in a sludge-blanket clarification plant followed by filtration through an anthracite filter, is capable of handling the greatest variations in oil contamination,
- b) Conventional coagulation and flocculation in alkaline conditions in a sedimentation plant, followed by filtration through an anthracite filter,
- c) Absorption of the oil by a pre-coat of aluminium hydroxide or ferric hydroxide upon a filter bed of anthracite or sand is capable of handling large flow rates at low levels of contamination,
- d) Absorption onto an expendable fixed bed of activated carbon substantially removes low levels, 1 to 2 mg/l, of oil.
- e) Filtration and absorption by a pre-coat of diatomaceous earth upon a filter candle is suitable for small flow rates and low levels, for example, 5 mg/l, of oil contamination.

3.2.4.5 The choice of treatment depends upon the amount of contamination, the type of oil and the amount and temperature of the condensate to be treated. It is difficult to measure accurately small concentrations of oil in water. It is recommended that treatment to remove oil should reduce it to a level that is not detectable by the method described in IS : 3025-1964*.

*Methods of sampling and test (physical and chemical) for water used in industry.

3.2.4.6 Each case needs individual consideration; but as a general guide methods that use diatomaceous earth or sand filtration may not be suitable, if a feed water of low silica content is required; and an anthracite filter bed should be used; methods based on continuous coagulation may be unsuitable where feed water of low dissolved solids content is required, unless the purified condensate is subsequently treated in a demineralizing plant.

3.3 The water obtained in **3.1** is mechanically de-aerated to remove air and dissolved gases. For water to be used for boilers operating above 5.9 MN/m^2 (60 kg/cm^2) a high degree of removal of oxygen should be attained; dissolved oxygen should preferably be less than 0.005 mg/l in the feed.

3.4 The de-aerated and degassed water is conditioned as given in **3.4.1** to **3.4.3**.

3.4.1 For the removal of traces of oxygen dissolved in the water, a suitable amine is used. Sodium sulphite, which is used in low and medium pressure boilers is unsuitable for use in high pressure boilers as it decomposes at high temperatures to produce sulphur dioxide or sodium sulphide or both, which are corrosive. The amine used generally is hydrazine. It reacts with oxygen from the water to form nitrogen and water. Thus neither the total solids are increased nor any corrosive substances produced in the boiler.

3.4.1.1 At higher temperatures in the boiler, hydrazine decomposes into ammonia and nitrogen. Ammonia and hydrazine being volatile, a portion of these two substances returns to the condensate. This makes the condensate alkaline and protects the condenser line from corrosion.

3.4.2 Phosphate is added to the boiler water in the drum to ensure the removal of any hardness-causing salts that might have accidentally found access to the feed water.

3.4.3 A certain amount of alkali is added to maintain the desired alkalinity in the boiler feed water. The alkali to be used may be amines or ammonia. A volatile amine such as cyclohexylamine or morpholine also may be added. Amines make the condensate alkaline.

4. CONTROL OF TREATMENT

4.1 Control of treatment is effected by examining feed water, boiler water, steam and condensate. Feed water is examined for hardness, dissolved oxygen, silica, hydrazine, pH, iron, copper, oil, conductivity and oxygen consumed in 4 hours. Boiler water is examined for pH, hardness, caustic alkalinity, dissolved solids, silica, phosphates, chlorides, and hydrazine. Condensate should be tested for pH, hardness, oil, silica, ammonia, sodium, dissolved oxygen and iron and copper, and demineralized water should also be tested for pH, silica and hardness from time to time.

4.2 In some modern high pressure boiler plants, instruments are fitted in the condensate line, feed system and stream lines which indicate and record conductivity, pH value and dissolved oxygen in the feed water; conductivity, and dissolved oxygen in condensate; and conductivity, and sodium in steam. These are often provided with warning alarms set at desired values. These aids are valuable in the operation of the boiler plant.

4.3 Control of Concentration of Solids in Boiler Water

4.3.1 When a water containing dissolved impurities is boiled and the vapour (steam) is driven off, most of the salts remain and concentrate in the diminishing bulk of water; thus the dissolved solids content increases. If the evaporation is continued some of the impurities come out of solution as scale or as suspended solids. These particular impurities will cease to concentrate as dissolved solids, but the suspended solids so formed concentrate.

4.3.1.1 In boiler design it is difficult to prevent the entrainment of small amounts of boiler water with the steam though this can be greatly limited. This entrainment normally increases with continuing concentration of dissolved and suspended solids and alkalinity. In order to limit the amount of solids in the steam it is necessary to control the concentrations of dissolved and suspended solids in the boiler water. At pressures greater than 3.9 MN/m^2 (40 kg/cm^2) some solids have a significant solubility in steam.

4.3.1.2 In practice one or several impurities in the boiler feed water may be critical with respect to their concentration in the boiler water. The following are examples:

- a) The level of dissolved solids should be restricted to maintain steam purity.
- b) The silica content may have to be restricted to limit the level of silica in the steam or the formation of silica scales in the boiler.
- c) In high pressure boilers the level of chloride ion should be limited to minimize corrosion.
- d) The level of alkalinity should be limited to maintain steam purity and minimize caustic attack.
- e) The level of suspended solids should be restricted to below that at which adherent deposits form, or steam purity or circulation are impaired.

4.3.1.3 The limits for these and other critical constituents are given in IS : 10496-1983*. In certain special cases of design or operation limitations may have to be imposed that are not covered by that standard; it is then normal for a boiler manufacturer to recommend values for the maximum concentration. In general these limits may be set from experience or determined by trial. Once set they should be scrupulously observed.

4.3.2 Blowdown — Blowdown may be continuous or intermittent, or a combination of both. It may be manually or automatically controlled.

4.3.2.1 Continuous blowdown — Continuous blowdown is a continuous removal of boiler water controlled by a specially designed adjustable valve or by an orifice plate. The installation of heat recovery equipment may be economically justified. Suspended solids may block or erode the adjustable valve or orifice plate and continuous blowdown is, therefore, usually limited to the control of dissolved solids. Additional manual blowdown is necessary to control suspended solids and prevent the build-up of sludge.

4.3.2.2 Intermittent Blowdown — Intermittent blowdown may be effected by specially designed valves either operated by hand or automatically controlled, for example, by timers, feed water flow or conductivity. Where automatic valves are installed the manual blowdown valve shall be operated at intervals to ensure that the latter is clear. It should be noted that the most effective and economic use of all types of intermittent blowdown valves is achieved by frequent full-open operation for short periods rather than extended use at infrequent intervals. It is usually not practicable to recover waste heat from infrequent intermittent blowdown.

5. PROTECTION OF IDLE BOILERS

5.1 Neglect of boilers during standing periods frequently leads to serious corrosion in the steam and water spaces from which further attack may develop during subsequent working periods. Various methods of corrosion protection may be applied although the choice of method usually depends upon the length of time for which the boiler is to be stored. Procedures for the protection of the fire-side of an idle boiler are outside the scope of this standard.

5.2 Storage Overnight or for a Few Days — It is usually sufficient to allow the boiler to stand-by with the water conditions recommended for normal steaming provided these are maintained during the idle period. Any feed water that is added subsequently should have been adequately

*Specification for feed water, boiler water and condensate for high pressure boilers.

de-aerated. The space above the water should preferably be kept filled with steam or nitrogen at a pressure greater than atmospheric. Special precautions may have to be taken to protect superheaters and expert advice should be sought.

5.3 Storage for Extended Periods

5.3.1 Wet Method — If the boiler is likely to be out of service for more than a few days, but may be needed for steaming at short notice, it should be completely filled with correctly conditioned water. Non-drainable superheaters should be filled only with condensate quality water treated with volatile chemicals such as hydrazine or ammonia. It is most important that pockets of air are not allowed to remain in the boiler and there should be no leakage.

5.3.1.1 When completely filling the boiler with water, sufficient ammonia and hydrazine should be added to combine with the dissolved oxygen and leave an excess of 100 mg/l to 200 mg/l hydrazine. In addition, sufficient ammonia should be added to ensure that a pH value of 9.5 to 10 is maintained. Distribution of these chemicals throughout the bulk of the water should be ensured by filling with a premixed solution or by use of a circulating pump or by heating the boiler when partially filled and then topping up with conditioned water.

5.3.1.2 It is recommended that the aircock on the drum or shell should be connected to a surge tank located at a higher level. This will compensate for any volumetric change and ensure a positive pressure, thus preventing admission of oxygen to the unit. This tank should be covered and kept dosed with oxygen scavenger and alkali. Alternatively, the pressure on the system should be maintained by using a small pump.

5.3.1.3 The oxygen scavenger reserve and the pH value or alkalinity should be checked regularly and additional treatment chemicals may have to be added at intervals and distributed to maintain the treatment levels within the recommended range. Any additional water added to the boiler, should contain the appropriate quantities of treatment chemicals.

5.3.1.4 When required for service, the boiler should be drained down to normal working level before firing. Phosphate or other conditioning reserves should be re-established as soon as possible.

5.3.1.5 This method of storage is not recommended if there is any likelihood of frost damage occurring. Wet storage is not recommended for periods longer than two to three months. It also tends to promote condensation of atmospheric moisture and hence corrosion in the flue-gas side; where this proves troublesome dry storage is to be preferred.

5.3.2 Dry Method — When a boiler is not likely to be required for a long period it is advisable to empty it completely and dry it thoroughly. Particular attention should be paid to any parts that are not self-draining. Where possible the boiler should be blown through with a stream of warm air to make sure that all surfaces are completely dry. Any deposits should be removed, since they tend to retain moisture. To avoid the ingress of moisture into the boiler it is advisable to remove and blank-off all connections.

5.3.2.1 Trays of silica gel or quick lime should be placed inside the boiler drum or shell, which should then be sealed. A typical quantity in practice is 1.5 kg/m^3 . Inspections should be made at intervals, initially after one week, and the desiccant dried or replaced as necessary. The trays and their contents should be removed before the boiler is restored to service.

6. CARE OF HIGH PRESSURE DRUM TYPE BOILER DURING CONDENSER TUBE LEAKAGE

6.1 Boiler water regime requires careful monitoring control and adjustment whenever condenser tube leakage is suspected or confirmed. The condenser tube leakage brings large amount of chlorides into the condensate and consequently into the feed water. This is more predominant in sea water cooled power stations where magnesium chloride and other forms of chlorides can leak in large quantities. These are hardness salts and acid forming in nature due to hydrolysis reaction at high temperature. Whenever the feed water gets contaminated by the cooling water leakage from the condenser the following changes take place in the boiler water in the drum:

- a) pH of boiler water drops rapidly due to the acid forming nature of condenser leakage salts.
- b) The phosphate level of boiler water drops down very low. This is due to consumption of the residual phosphate by its reaction with hardness in leakage salts to form sludge constituents.
- c) Conductivity of boiler water rises due to increasing salt concentration brought about by condenser leak.

6.2 Under these circumstances, experience indicates accelerated corrosion of boiler tubes and consequent tube failures can be caused even if such operation is limited only to a few hours. In such a situation, the following course of action is recommended. It should be realised that operation of the boiler with a condenser leak requires extreme care and judgement. Failure to follow instructions would lead to tube failure at a later stage.

- a) Immediately start chemical injection pumps to maintain excess phosphate and pH conditions in boiler water as below:

Characteristic	Limits Recommended	
	For boiler pressure 6.0 to 9.8 MN/m ² (in the drum)	For boiler pressure 9.9 MN/m ² (in the drum) and above
Phosphates (as PO ₄), mg/l	5 to 40	5 to 20
pH value	9.1 to 10.4	9.1 to 10.1

The phosphate and pH measurements in boiler water should be made every 30 minutes and the phosphate pump should be operated based on the measurements to maintain the above regime. This would require, depending on the severity of tube leakage, extra dosage of phosphate. This can be done either by increased running of the phosphate pump at the maximum capacity or by increasing the strength of the phosphate solution charged to the tank.

Some operators rely on dosing caustic soda (NaOH) in boiler drum under such conditions to restore quickly the boiler water pH. Caustic soda dosing should be done with utmost care, as concentration of free hydroxide may lead to corrosion of boiler tubes. In such cases caustic and phosphate (preferably disodium phosphate) shall be combinedly dozed together and the pH and phosphate content shall be closely monitored such that pH for the corresponding phosphate residual does not fall above the curve (Fig. 1). The region above the curve indicates the presence of free hydroxide.

NOTE — Operation above the curve, which results in free hydroxide, is to be avoided.

- b) Increase blow down to the extent possible to keep the conductivity in boiler within the limits given below:

Boiler Pressures (in the Drum), MN/m ²	Specific Electrical Con- ductivity at 25°C, Microsiemens/cm
6.0-9.8	400
9.9-11.8	200
11.9 and above	100

- c) Monitor the following at an interval of every 30 minutes.
- Condensate sample either from ejector or from hot well for conductivity.
 - Boiler water sample for pH, phosphate, and conductivity.

- d) Isolate the condenser section one by one for locating the damaged section and isolate and repair the damaged section. (If damaged condenser section cannot be isolated and repaired, shut down the unit.)
- e) Do not continue to operate the unit if pH of boiler water cannot be maintained above 8.0 or the conductivity as given 6.2(b).
- f) Avoid unnecessary use of desuperheater spray by permitting reheat temperature to fall or by reducing load.
- g) If the unit is shut down for condenser repair, drain and flush the system to the extent possible and establish wet lay-up of boiler unit and auxiliary equipment during condenser repair.

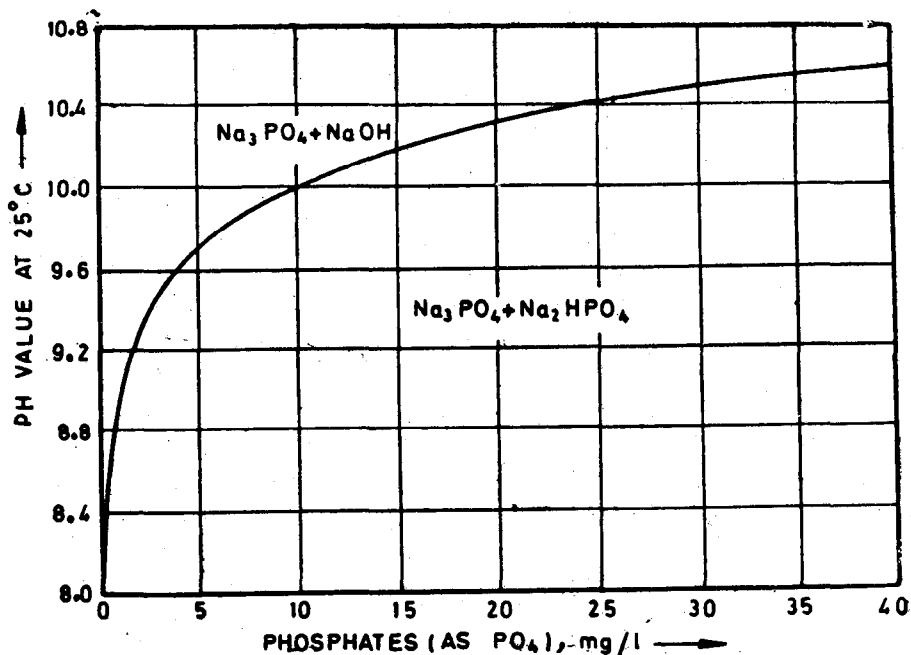


FIG. 1 RECOMMENDED COORDINATED PHOSPHATE CURVE

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R14 Yudhister Marg, C Scheme, JAIPUR 302005		6 34 71
117/418 B Sarvodaya Nagar, KANPUR 208005		21 68 76
Plot No. A-9, House No. 561/63, Sindhu Nagar, Kanpur Road, LUCKNOW 226005		5 55 07
Patliputra Industrial Estate, PATNA 800013		6 23 05
District Industries Centre Complex, Bagh-e-Ali Maidan, SRINAGAR 190011		—
T. C. No. 14/1421, University P. O., Palayam, THIRUVANANTHAPURAM 695034		6 21 04
<i>Inspection Offices (With Sale Point) :</i>		
Pushpanjali, First Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010		52 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005		5 24 35
*Sales Office Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, CALCUTTA		27 68 00
† Sales Office is at Novelty Chambers, Grant Road, BOMBAY		89 65 28
‡ Sales Office is at Unity Building, Narasimhara Square, BANGALORE		22 39 71